

DEFICIENCIES OF MAJOR NUTRIENT ELEMENTS IN *PROTEA CYNAROIDES* LINN., GROWN IN SAND CULTURE

I. FOLIAR SYMPTOMS OF DEFICIENCIES

J. VAN STADEN

(*Department of Botany, University College of the Western Cape,
Bellville, South Africa*)*

ABSTRACT

Foliar symptoms of deficiencies of the major nutrient elements (N, P, K, Ca, Mg, S, and Fe) of the giant protea, *Protea cynaroides*, were recorded in respect of plants grown in sand culture. In general these symptoms corresponded to those previously described for other species.

INTRODUCTION

Relatively little is known concerning the nutrient requirements of indigenous South African plants. This is especially true of the Proteaceae (Schütte, 1960).

Because of the present interest in the breeding of this family of flowering plants, and their cultivation on a commercial scale, it has become important to know more about their physiology and in particular about their nutritional requirements. It was therefore decided to cultivate a member of the Proteaceae under greenhouse conditions, in order to study its reactions towards different nutrient elements. This study, which was undertaken with *P. cynaroides* Linn., appears to be the first attempt in this respect.

The present paper describes the symptoms resulting from deficiencies of the major nutrient elements. A subsequent paper will deal with the growth results and chemical composition of the plants.

*Present address: Bews Botanical Laboratory, University of Natal, Pietermaritzburg, Rep. of South Africa.

MATERIAL AND METHODS

Seeds of *Protea cynaroides* Linn. (collected near Port Elizabeth) were germinated in flats of sand. After the expansion of two true leaves one plant was transferred to each of 24 clay pots, eight inches in diameter, with a drainage hole in the bottom. The pots were heavily coated with bitumastic paint and filled with acid-washed sand. The plants were grown in a greenhouse maintained between 8° and 30° C.

The nutrient solutions were made up with deionised water. Their composition is shown in Table 1.

TABLE I
Composition of nutrient solutions used for the development of major nutrient element deficiencies in sand culture

				Ml. of stock solution per litre of nutrient							
				Complete (control)	-N	-P	-K	-Ca	-Mg	-S	-Fe
Ca (NO ₃) ₂ ·4H ₂ O	..	..	..	5	—	5	5	—	5	5	5
KNO ₃	..	..	..	5	—	5	—	5	5	5	5
MgSO ₄ ·7H ₂ O	..	..	..	2	2	2	2	—	—	—	2
KH ₂ PO ₄	..	..	..	1	1	—	—	1	1	1	1
NaNO ₃	..	..	..	—	—	—	5	10	—	—	—
MgCl ₂	..	..	..	—	—	—	—	—	—	2	—
Na ₂ SO ₄ (0·5 M)	..	..	..	—	—	—	—	—	4	—	—
NaH ₂ PO ₄ ·2H ₂ O	..	..	..	—	—	—	1	—	—	—	—
CaCl ₂ ·2H ₂ O	..	..	..	—	5	—	—	—	—	—	—
KCl	..	..	..	—	—	1	—	—	—	—	—
K ₂ SO ₄ (0·5 M)	..	..	..	—	5	—	—	—	—	—	—
Fe-EDTA (0·5%)	..	..	..	3	3	3	3	3	3	3	—
Micronutrients*	..	..	..	2	2	2	2	2	2	2	2

* Stock trace element solution: 2.86g H₃BO₃; 1.80g MnCl₂·4H₂O; 0.11g ZnCl₂; 0.054g CuCl₂·2H₂O; and 0.02g H₂MoO₄·2H₂O per litre.

Each container was drenched daily with 500 ml. of the appropriate nutrient solution. The effluent was collected in a second bottle, made up to 500 ml. with deionised water, and the process repeated the following day. Nutrient solutions were changed once per week. From time to time the sand was leached thoroughly with deionised water.

For the first four weeks a complete nutrient solution was applied at half strength and subsequently at full strength. One week later the different nutrient solutions listed in Table 1 were applied. Prior to application the pH of each solution was adjusted to 6.0 with N NaOH. As a result of this procedure all plants except the controls died. The experiment was thereupon repeated, with the difference that the complete nutrient solution was applied for 31 weeks before commencing the different treatments. After another ten weeks, all except the control plants had developed deficiency symptoms. These were carefully noted and the plants photographed before harvesting.

DEFICIENCY SYMPTOMS

Nitrogen deficiency: The oldest leaves showed the first clear symptoms. In the early stages they were pale, yellowish-green. These symptoms progressed upwards in the direction of the tips of shoots; more or less at the same time the tips of the old leaves showed severe signs of chlorosis. Brown areas appeared in the centre of the laminae of the oldest leaves. This phenomenon was accompanied by the development of necrotic areas, which spread from the leaf tips towards the petioles. Shortly afterwards the old leaves abscised.

Nitrogen deficiency had the most profound effect on the general growth of the plants. They remained stunted and some of the plants died.

Phosphorus deficiency: The symptoms produced in the absence of phosphorus were in many ways similar to those resulting from nitrogen deficiency. The first symptoms appeared in the oldest leaves. As in the case of nitrogen deficiency the leaf tips were chlorotic, while the rest of each leaf had a dull bluish-green colour. Purple tints first appeared as isolated areas on the petioles, from where they spread to the leaf margins. Subsequently the laminae of the leaves tended to curl upwards and forwards.

The leaves were generally small in comparison to those of the control plants, older leaves were shed prematurely.

Potassium deficiency: Deficiency symptoms appeared first on the older leaves. At first necrotic areas appeared at the tips of the leaves (tip burn), from where they spread along the margins towards the petioles. The lateral shoots showed severe symptoms of die-back. The leaves had a dull bluish-green colour, with light-yellow spots in interveinal areas. These spots gradually turned brown; similar spots developed on the petioles. Soon after the appearance of the brown areas the leaf laminae started curling upwards. The leaves abscised when approximately two-thirds of their laminae had become necrotic.

Calcium deficiency: The first of calcium deficiency appeared as a general spindliness of the stems, with the young leaves showing irregular forms. After some time necrotic areas developed along the margins of the older leaves. The necrosis progressed until all the leaves were dead, leaving only the growing points of the stems intact; these probably would have died later. When harvested, it was found that the stems and roots had a gelatinous consistency (Plate I).

Magnesium deficiency: Symptoms first appeared on the oldest leaves, the tips of which turned chlorotic. Subsequently the interveinal regions turned slightly chlorotic. The leaf tips died and the leaf margins curled upwards. Brown spots appeared on the petioles and some of the leaf veins turned purple. These symptoms generally did not progress any further, but in a few cases the brown and purple areas turned necrotic (Plate II).



PLATE I. *Protea cynaroides* in sand culture.
Calcium deficiency:
Old leaves dead; plant gelatinous when harvested.



PLATE II. *Protea cynaroides* in sand culture.
Magnesium deficiency:
Tips of older leaves chlorotic, necrosis developing; purple spots on petioles.

Sulphur deficiency: There were no well-defined symptoms, although the leaves became somewhat chlorotic. Chlorosis first appeared along the leaf margins and gradually spread towards the mid-ribs. Later a number of veins and leaf margins developed high red tints.

Iron deficiency: Chlorosis developed first in the young leaves, and spread downwards towards the older leaves. At first the chlorosis assumed a mottled pattern, while the veins were yellowish-green. As the symptoms progressed, the interveinal areas turned yellow and small necrotic areas developed (Plate III).



PLATE III. *Protea cynaroides* in sand culture.

Iron deficiency:

Severe chlorosis of leaves; most severe on younger growth. Foreground: A small *Protea eximia* plant showing the same symptoms as *P. cynaroides*.

CONCLUSIONS

The deficiency symptoms which developed in the absence of the different major nutrient elements are essentially similar to those which have been described for other plants (Wallace, 1961; Lockard and Asomaning, 1964; Nichols, 1964). Certain symptoms, e.g. chlorosis, were common to several deficiencies.

The symptoms of a deficiency of nitrogen, phosphorus, potassium, and magnesium all started at the basal leaves, and developed in an upward direction towards the tips of the shoots. In the case of calcium-deficient plants the young leaves first showed malformations, but the older leaves died first, with necrosis progressing towards the younger parts of the plants. Although one might recognise a plant as suffering from malnutrition, it might prove difficult to diagnose specific nutrient deficiencies of *Protea cynaroides* in the field.

A few plants of *Protea barbiger* and *Protea eximia* were grown under conditions similar to those of *P. cynaroides*, and developed deficiency symptoms which corresponded to those described in this report.

ACKNOWLEDGEMENTS

This investigation was supported by a grant from the C.S.I.R., for which I am most grateful.

I wish to thank Dr. J. A. de Bruyn for his assistance with the preparation of the manuscript.

REFERENCES

- LOCKARD, R. G. and ASOMANING, E. J. A. (1964): Mineral nutrition of cacao (*Theobroma cacao* L.) I. Deficiency symptoms and nutrient levels in plants grown in sand culture. *Plant and Soil* **21**: 142-152.
- NICHOLS, R. (1964): Studies on the major-element deficiencies of the pigeon pea (*Cajanus cajan*) in sand culture. I. Foliar symptoms of the major-element deficiencies. *Plant and Soil* **21**: 377-387.
- SCHÜTTE, K. H. (1960): Trace element deficiencies in Cape vegetation. *J. S. Afr. Bot.* **16**: 45-49.
- WALLACE, T. (1961): *The diagnosis of mineral deficiencies in plants by visual symptoms*. Her Majesty's Stationery Office, London.